SUGARBUSH RESIDENTIAL DEVELOPMENT PROJECT

APPENDIX M

GEOTECHNICAL INVESTIGATION

GPA 05-010/TM 5295RPL7/R04-008/SP 03-003/
S04-015/LOG NO. 02-08-047
SCH NO. 2005121098

for the

DRAFT FINAL ENVIRONMENTAL IMPACT REPORT

AUGUST 2010

GEOTECHNICAL INVESTIGATION

BUENA CREEK SUBDIVISION
SUGARBUSH DRIVE
VISTA, CALIFORNIA

JOB NO. 02-11

AUGUST 21, 2002

WESTERN
SOIL AND FOUNDATION ENGINEERING, INC.

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August 29, 2002

Sugarbush L.L.C.
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Venture Pacific Development
P.O. Box 231639
Encinitas, CA 92023-1639

Project: Job No. 02-11
Buena Creek Subdivision
Sugarbush Drive
Vista, California

Subject: USDA Soil Identification

Dear Mr. Booker:

Our review of the Soil Survey for the San Diego Area (USDA, 1973) identifies the Huerhuero Loam (HrC2) as covering a significant portion of the western, gently sloping areas of the referenced site. In accordance with your request, we have compared the soil descriptions provided in our exploratory excavation logs with the physical characteristics of the Huerhuero Loam identified in the USDA Soil Survey.

According to this survey, the Huerhuero Loam is described as a slightly sticky, slightly plastic loam with clay subsoil that typically extends from 2 to 5½ feet below the surface. It is developed upon sandy marine sediments, with a "clear, smooth boundary" that exists between the Huerhuero Loam and its parent bedrock. According to the referenced document, the Huerhuero Loam has a "high" shrink-swell behavior with low to moderate plasticity (CL in the Unified Soil Classification System).

Exploratory backhoe trenches were excavated on the subject site as part of a geotechnical investigation. Four of these excavations were located within the western, gently sloping areas of the property. The soils exposed in our trenches consisted of brown, silty, fine and silty, fine to medium grained sand; and reddish-brown, sandy silt with minor lenses of clayey silt and angular rock fragments. An expansion index test, performed on a visibly "sticky" lense of soil resulted in a low expansion potential (shrink-swell).

The parent bedrock predominantly was a fine to medium grained, slightly decomposed granitic rock (Green Valley Tonalite). At one location, the bedrock was brecciated, meta-volcanic rock (Santiago Peak Volcanics). The contact between the overburden soil and bedrock varied from gradational to sharp and undulating. The depth to bedrock ranged from 2½ to 6 feet.

In conclusion, the developed soils exposed within our exploratory excavations have physical characteristics that are distinctly different from those ascribed to the Huerhuero Loam.

If you have any questions, please do not hesitate to contact this office. This opportunity to be of professional service is sincerely appreciated.

Respectfully submitted,
WESTERN SOIL AND FOUNDATION ENGINEERING, INC.

Vincent W. Gaby, CEG 1755, Expires 7/31/03
Engineering Geologist

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Project: Job No. 02-11
Buena Creek Subdivision
Sugarbush Drive
Vista, California

Subject: Report of Geotechnical Investigation

Dear Mr. Booker:

In accordance with your request, we have completed a geotechnical investigation for the proposed project. We are presenting to you, herewith, our findings, conclusions and recommendations for the development of this site.

The findings and conclusions of this study indicate that the site is suitable for development if the recommendations provided in the attached report are incorporated into the design and construction of this project.

If you have any questions after reviewing the findings and recommendations contained in the attached report, please do not hesitate to contact this office. This opportunity to be of professional service is sincerely appreciated.

Respectfully submitted,
WESTERN SOIL AND FOUNDATION ENGINEERING, INC.

Vincent W. Gaby, CEG 1755, Expires 7/31/03
Engineering Geologist

Dennis E. Zimmerman, C 26676, GE 928, Expires 3/31/04
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GEOTECHNICAL INVESTIGATION

BUENA CREEK SUBDIVISION
SUGARBUSH DRIVE
VISTA, CALIFORNIA

Prepared For:

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AUGUST 21, 2002

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TABLE OF CONTENTS

Page

Introduction and Project Description 1

Project Scope 2

Findings 3
- Site Description 3
- Subsurface Conditions 3
- Santiago Peak Volcanics 4
- Tonalite 4
- Alluvium 5
- Colluvium 5
- Rippability 5
- Groundwater 6

Geologic Hazards 7
- Faults and Seismic Hazards 7
- Seismicity of Major Faults 8
- Liquefaction 9
- Landslides and Slope Stability 9

Recommendations and Conclusions 10
- Site Preparation 10
  - General 10
- Rock Fills 11
  - Expansive Soil 13
  - Imported Fill 13
  - Earthwork 13
  - Cut Slopes 14
  - Fill Slopes 15
  - Surface Drainage 16
  - Subdrains 16

TABLE OF CONTENTS – Con't.

Page

Foundation Recommendations....................17
Seismic Site Categorization....................17
Footings....................18
Concrete Slabs-On-Grade....................19
Transition Areas....................20
Lateral Resistance....................21
Lateral Resistance Values....................21
Footing Observations....................21
Pavement Recommendations....................22
General....................22
Preliminary Pavement Design....................22
Base Materials....................23
Field Explorations....................24
Laboratory Testing....................24
Plan Review....................25
Limitations....................25

ATTACHMENTS

Plate Number 1	Site Plan (In back pocket)
Plate Number 2	Unified Soil Classification Chart
Plate Numbers 3 through 23	Exploratory Trench Logs
Plate Numbers 24 and 25	Laboratory Test Results
Plate Number 26	Table I
Plate Number 27	Fill Slope Key
APPENDIX I	Specifications for Construction of Controlled Fills
APPENDIX II	References

GEOTECHNICAL INVESTIGATION

BUENA CREEK SUBDIVISION
SUGARBUSH DRIVE
VISTA, CALIFORNIA

Introduction and Project Description

This report presents the results of our geotechnical investigation performed on the above referenced site. The purpose of this investigation was to evaluate the existing surface and subsurface conditions from a geotechnical perspective and to provide recommendations for grading, foundation design, floor slab support and structural pavement design.

The proposed project will be the development of a residential subdivision consisting of 47 residential lots and 5 open space lots. A network of interior streets will provide access to the development from Sugarbush Drive. Based on the preliminary site development plan provided by BHA, Inc., the earthwork is expected to result in average elevation changes on the order of 10 to 20 feet. Maximum cuts and fills are anticipated to approach 25 and 40 feet, respectively.

Building plans were not available, however, it is anticipated that the residences will consist of 1- or 2-story, wood-framed structures supported on continuous and square pad spread footings with concrete slab-on-grade floors.

The recommendations presented herein are based on the conceptual drawings and verbal descriptions provided. We should be allowed the opportunity to amend our recommendations, if necessary, after our review of final plans. If any future development deviates significantly from our understanding of the project described above, we should be consulted for further recommendations.

The site configuration and the approximate locations of our subsurface explorations are shown on the enclosed Site Plan, Plate No 1, located in the back pocket of this report.

Project Scope

This investigation consisted of a surface reconnaissance coupled with a subsurface exploration. Representative samples of soil material were obtained from the site and returned to our laboratory for observation and testing. The results of the field and laboratory data collected are presented in this report.

Specifically, the intent of this investigation was to:

a) Explore the subsurface conditions to the depths that could be influenced by the proposed construction;

b) Evaluate, by laboratory tests, the pertinent static physical properties of the various soil and rock stratigraphic units which could influence the development of this project;

c) Describe the site geology, including potential geologic hazards and their effect upon the proposed development;

d) Provide recommendations for site preparation and grading;

e) Furnish soil parameters for foundation design, including bearing capacity, estimated settlements, lateral pressures, and expansion potential of the on-site soils; and

f) Present a preliminary structural pavement section for the proposed residential roads.

This report has been prepared for Mr. Bob Booker, Managing Member, Sugarbush L.L.C. to be used in the evaluation of the referenced site. This report has not been prepared for use by other parties, and may not contain sufficient information for purposes of other parties or other uses. The information in this report represents professional opinions that have been developed using that degree of care and skill ordinarily exercised, under similar circumstances, by reputable geotechnical consultants practicing in this or similar localities. No other warranty, express or implied, is made as to the professional advice included in this report.

Findings

Site Description: The project site is located south of Buena Creek Road, at the south end of Sugarbush Drive and the east end of Cleveland Trail, east of the Vista city limits, in the county of San Diego, California. The majority of the site can be found in grids E-1 and E-2, page 1108, of the Thomas Brothers Guide for San Diego County, 2002 edition.

The subject property is irregular in configuration and encompasses approximately 115 acres. It is bounded to the north and west by residential and agricultural property. Undeveloped property abuts the east and south property lines.

The site topography consists of a series of hills and canyons. The terrain varies from very steep to gently inclined. Remnant agricultural service roads provide access across the site. Elevations across the property range from 1,050 feet above mean sea level (m.s.l.) at the northeast portion of the property to 565 feet m.s.l. in the bottom of an arroyo as it exits the west side of the property. Drainage is by generally westward sheet flow into tributary arroyos that empty into Buena Creek.

No structural improvements were observed on the site at the time of our investigation. An excavation, presumably used in the past as a pond or reservoir, occurs near the eastern boundary. Vegetation across the site consisted of miscellaneous trees, indigenous chaparral and wild grasses.

Subsurface Conditions: The subject site is underlain by metamorphic bedrock of the Santiago Peak Volcanics and crystalline granitic bedrock (tonalite) that is considered a part of the Cretaceous age southern California batholith. The bedrock materials are mantled by alluvium and colluvium. Each unit is described below in order from oldest to youngest.

Santiago Peak Volcanics: The Santiago Peak Volcanics observed on the site consist of metamorphosed volcanic and volcaniclastic rocks. Their color varies from greenish-gray to bluish-gray. They are very hard and resistant, yet locally fractured. The metamorphic bedrock generally appears to be suitable to support foundations and properly compacted fill.

Excavation with the backhoe was moderately to extremely difficult. The materials generated during our exploration of the Santiago Peak Volcanics consisted of silty, sandy, angular pebble to cobble.

Tonalite: The crystalline bedrock exposed in the exploratory trenches consists of orangish-brown to orangish-gray to gray, fine and fine to medium grained, variably weathered granitic rock (tonalite). Its mineral constituents are predominantly plagioclase feldspar with minor amounts of alkali feldspar and quartz. Mafic minerals, mainly biotite and hornblende, make up approximately 15 to 20 percent. Similar bedrock within the site vicinity has been mapped by Tan and Kennedy (1996) as the Green Valley Tonalite. Moderate jointing occurs within this bedrock and individual joints are generally closed with rough surfaces. Near the contact with the overlying surface soils, the tonalite weathers to a granitic residuum. The composition of the residual soil generally reflects the nature of the bedrock from which it develops. At the locations explored, the residuum consists of orangish to reddish-brown, clayey to silty, fine to medium grained sand. The residuum often retains the characteristics (jointing, foliations, and intrusions) present in the parent bedrock.

The tonalite is typically dense to very dense and should provide adequate support for foundations or the placement of new fill.

Alluvium: Alluvium generally occurred within the significant drainage courses present on the site. It was composed of dark brown, sandy silt with angular cobble and pebble of metamorphic rock. It was typically damp to very moist and poorly indurated. In its present condition, it is not considered suitable for the support of foundations, pavements, fill soils or other structural improvements.

Colluvium: At the locations explored, poorly consolidated colluvium ranging from 1 to 3 feet in thickness was observed mantling the bedrock materials. For the purposes of this study, the term colluvium is used to describe reworked soil and slope wash as well as in situ developed soil. Its composition was generally influenced by the bedrock materials from which it originated and upon which it was developed. When derived from the metamorphic bedrock, these soils typically consisted of dark brown, sandy to clayey silt with localized angular pebble to cobble. Colluvium originating from granitic bedrock usually consisted of orangish-brown to brown, silty, fine grained and silty, fine to medium grained sands. In its present condition, the colluvium is not considered suitable for the support of foundations or fill.

Rippability: Twenty-one (21) exploratory trenches were excavated with moderate to extreme difficulty using a Ford 555C backhoe. These trenches ranged from 3 to 14 feet in depth. Refusal or near refusal was encountered on both metamorphic and granitic bedrock at varying depths within 14 of these trenches. For the purposes of this study, refusal is defined as the inability of the backhoe to excavate the bedrock materials. Near refusal is a subjective determination and describes the inability of the backhoe to excavate more than about 6 inches within a 15-minute period. Our observations are presented in the table below.

Apparent Rippability

Trench Location	Depth to Near Refusal (feet)	Depth to Refusal (feet)	Trench Location	Depth to Near Refusal (feet)	Depth to Refusal (feet)
T-3	5		T-13	3	
T-4		5½	T-14		4½
T-5	4		T-15		3
T-6	8		T-17	5	
T-7	9		T-18	5	
T-9		3	T-20	3	
T-10	5		T-21		7

It is our opinion that heavy-duty equipment, similar to a D-9 with a single tooth ripper, could excavate these materials at least a few feet deeper. However, it is likely that hard, unfractured resistant bedrock and/or boulders that require blasting or pneumatic chipping may be encountered at locations or depths that were not explored.

Groundwater: Free groundwater was not observed in our exploratory excavations. However, due to the relatively low permeability of the hard, unfractured metamorphic bedrock, localized zones of perched water may develop following episodes of heavy precipitation and/or excessive irrigation. This would be expected to occur in the arroyos and lower elevations of the property.

It should be noted that fluctuations of subsurface water will be affected by variations in annual precipitation and local irrigation. Moreover, it has been our experience that periodic events of seepage will occur in areas of significant "cut" or any "below-grade" structures. Therefore, consideration must be given to appropriate surface and subsurface drainage systems such as underdrains and swales as recommended further in this report.

Geologic Hazards

Faults and Seismic Hazards: The numerous fault zones in southern California include active, potentially active, and inactive faults. Active faults are those which display evidence of movement within Holocene time (from the present to approximately 11 thousand years). Faults that have ruptured geologic units of Pleistocene age (11 thousand to 2 million years) but not Holocene age materials, are considered potentially active. Inactive faults are those which exhibit movement that is older than 2 million years. According to available published information, there are no known active or potentially active faults which intercept the project site.

The site is not located within an Alquist-Priolo Special Studies Zone. Therefore, the potential for ground rupture at this site is considered low. There are, however, several faults located in close proximity that movement associated with them could cause significant ground motion at the site. The table below presents the maximum credible earthquake magnitudes and estimated peak accelerations anticipated at the site. These accelerations are based on the assumption that the maximum credible earthquake occurs on specific faults at the closest point on that particular fault to the site. The maximum credible earthquake is defined as the maximum earthquake that appears to be reasonably capable of occurring under the conditions of the presently known geologic framework. The probability of such an earthquake occurring during the lifetime of this project is considered low. The severity of ground motion is not anticipated to be any greater at this location than in other areas of San Diego County.

Seismicity of Major Faults

Fault	Distance (Miles)	Maximum Credible Magnitude (Richter)	Estimated Bedrock Acceleration (1) (g)
Coronado Banks	30	7.6 L (2)	0.19
Elsinore	16	7.5 L (3)	0.32
Rose Canyon	14	7.0 L (2)	0.30
San Andreas	65	8.3 L (3)	0.11
San Jacinto	39	7.8 L (3)	0.16

L = Local Magnitude

(1) Seed and Idriss, 1982
(2) Slemmons, 1979
(3) Greensfelder, C.D.M.G. Map Sheet 23, 1994

The preceding table suggests that the Elsinore and Rose Canyon fault zones would have the predominant influence on the site. The postulated design earthquake and ground accelerations are presented in the table below.

Design Earthquake

Fault Zone Source	Maximum Credible Magnitude (Richter)	Peak Ground Acceleration (g)	*Sustained Acceleration (g)
Elsinore	7.5	0.32	0.21
Rose Canyon	7.0	0.30	0.20

*Sustained Acceleration considered
65% of peak ground acceleration

Liquefaction: The potential for seismically induced liquefaction is greatest where shallow groundwater and poorly consolidated, well sorted, fine grained sands and silts are present. Liquefaction potential decreases with increasing density, grain size, clay content and gravel content. Conversely, liquefaction potential increases as the ground acceleration and duration of seismic shaking increase.

Groundwater was not observed within any of our explorations, and the area of proposed development is underlain by very hard metamorphic bedrock and dense crystalline granitic bedrock. Based on the consistency of the underlying materials and the anticipated recompaction of overburden soils, the potential for generalized liquefaction in the event of a strong to moderate earthquake on nearby faults is considered low.

Landslides and Slope Stability: No evidence indicating the presence of deep-seated landslides was observed on or in the immediate vicinity of the site. The underlying formational materials observed in our exploratory excavations consisted of hard metamorphic and dense granitic bedrock. Significant shear zones, displaced stratigraphy or severely brecciated bedrock were not encountered in these materials. It is therefore our opinion that the potential for deep seated slope failure on this project is low.

However, fractures and jointing within both the metamorphic and granitic bedrock may create potential shallow rock falls at isolated areas in constructed cut slopes. Observation of the cut slopes during and after grading will be important to identify potential shallow slope failures and rock falls. It is anticipated that any incompetent soil materials encountered during the earthwork will be mitigated as recommended further in this report. Therefore, the potential for slope failure on this project is considered low.

Recommendations and Conclusions

Site Preparation

General: The incompetent overburden soils (alluvium and colluvium) encountered during our subsurface exploration are not considered suitable for the support of foundations, pavements, fill or other structural improvements in their present condition. To provide more uniform support for the proposed structures and prior to the placement of any new fill, we recommend that any existing fill, alluvium, colluvium or otherwise unsuitable material be completely removed to firm undisturbed natural ground. These soils may be used as properly compacted fill in accordance with the recommendations which follow in this report.

The horizontal limits of removal and recompaction shall include the entire areas of proposed structures, fill or any proposed fill slopes. All soil removal and replacement should extend at least 5 feet beyond the footprint of any structures and shall be accomplished in accordance with the earthwork and foundation recommendations presented in this report.

Based on the results of our field explorations, it appears that the depth of removal will range from 1 to 5½ feet. Table I (Plate No. 26) of this report presents anticipated removal depths in the area of our subsurface explorations. Thicker and/or less competent materials may be encountered at locations that were not explored. Unsuitable soils that occur beneath areas to receive retaining walls, asphalt or concrete pavements, driveways, patio slabs or sidewalks shall be treated similarly.

The on-site soils minus any debris or organic material may be used as controlled fill. All fill shall be compacted to at least 90% of its maximum dry density as determined by ASTM D1557-91 (Reapproved 1998). The moisture content at the time of compaction should be within 2% of optimum for non-expansive soils and between 2% and 4% over optimum for the clayey materials. All debris or organic matter encountered must be removed and legally disposed of at a licensed disposal site. Oversized materials (greater than 6 inches in maximum dimension) may be placed in rock fills as described further in this report.

If groundwater is encountered during the removal and recompaction of the soil, or if difficulty is experienced in achieving the minimum of 90% relative compaction (ASTM D1557-91), then this office shall be consulted for further recommendations.

Rock Fills: Due to the abundance of bedrock underlying the site and the anticipated deep cuts, substantial quantities of oversized rock (1 to 4 feet in greatest dimension) may be generated on the site. We are therefore presenting these recommendations for the placement of rock fills. Two methods of placing oversized rock in structural fill areas may be employed on site. These methods (windrowing or rock-mat fill) are described below.

1) **Windrowing:** Windrowing of oversized rock will entail the placement of single file rows of rock material larger than twelve inches but less than 4 feet in greatest dimension. The rock shall be placed in "V" shaped trenches cut at least two feet into well-compacted soil fill or dense natural ground. Windrow trenches shall be cut parallel to each other and separated horizontally by a distance of 15 feet. The top elevation of each windrow course shall be separated from the bottom elevation of the next overlying course by a vertical distance of 4 feet. Individual windrows shall be staggered or offset from individual windrows in the vertically adjacent course such that no windrow will exist directly above or below an adjacent windrow. Rocks placed in windrows shall be separated a minimum distance of one foot, end-to-end. The voids around and beneath rocks must be completely filled with approved granular soil having a sand equivalent of 25 or greater. This void-filling soil shall be compacted by flooding and/or mechanical methods. Windrows shall not be placed closer than 10 feet to any proposed fill slope face or within 6 feet of finish grade elevation. Deeper separations between finish grade elevation and the top of the windrows may be necessary where pools or other below-grade structures are proposed.

2) **Rock-Mat Fill:** A rock-mat fill consists of oversized rock material tightly nested together with rock-to-rock contact and whose voids are filled with finer-grained material. Oversized rock shall be no more than 2 feet in greatest dimension. A rock-mat fill shall be placed with sufficient amount of finer-grained material of various gradations to help fill interstices during placement. Fine grained material may consist of approved on-site granular soil material. Topsoil, silts, clays or other similar types of soil material shall not be used as fines. Material used as fines shall be approved by our firm and shall have a minimum sand equivalent of 25. The volume of fines shall be sufficient to fill all voids between large and small rocks.

The base of the rock fill shall be placed on a sloping surface (minimum slope of two percent, maximum slope of six percent). The surface shall slope toward a subdrain. The subdrain shall be placed 18 inches below the subgrade that is to receive the proposed rock-mat fill.

Rock-mat fills shall be placed in lifts not exceeding 3 feet. Placement shall be by rock trucks, loaders or other suitable equipment traversing previously placed lifts and dumping at the edge of the currently placed lift. Spreading of the rock-mat fill shall be by dozer to facilitate "seating" of the rock.

The rock-mat fill shall be watered heavily during placement. Watering shall consist of water truck(s) traversing in front of each rock lift face and spraying water continuously during rock placement. Compaction equipment providing suitable energy to achieve the required compaction shall be utilized. The number of passes to be made will be determined by the Soil Engineer or his representative.

A representative of the Soil Engineer shall be present during rock fill operations to verify that specified procedures are being followed. Rock-mat fills shall not be placed closer than 10 feet to any proposed fill slope face or within 6 feet of pad finish grade elevation. Deeper separations between finish grade elevation and the top of the rock fill may be necessary where pools or other below-grade structures are proposed. Within these confines, the rock-mat fill should be continuous across any one building pad to avoid differential settlement between soil fill and rock fills.

Expansive Soil: Detrimentally expansive soils (Expansion Index of 21 or greater) were encountered during our subsurface exploration. These materials typically occurred within the clayey portion of the colluvium and alluvium. The results of laboratory testing indicate that they have a low expansion potential (Expansion Index of 21 to 50). We recommend that these soils be placed within the deeper proposed fill areas, placed outside the location of structural improvements or legally exported from the site. Potentially expansive soil should not be placed within 4 feet of finish grade. Building envelopes should be capped with soil material having an expansion index of 20 or less. It is anticipated that suitable capping material should be available within the decomposed granitic materials on the site. Expansive soils should not be used as wall backfill or within 4 feet of finish subgrade in paved or hardscaped areas.

Imported Fill: Imported fill, if required at this site, shall be approved by our office prior to importing. The Soils Engineer should be notified at least 72 hours prior to importing so as to have ample time to sample, test and evaluate potential import materials. Imported fill material shall have an Expansion Index of 20 or less with not more than 25 percent passing the No. 200 U.S. standard sieve.

Earthwork: All earthwork performed on-site must be accomplished in accordance with the attached Specifications for Construction of Controlled Fills (Appendix 1). All special site preparation recommendations presented in this report will supersede those in the Specifications for Construction of Controlled Fills.

All embankments, structural fill, and utility trench backfill shall be compacted to no less than 90% of its maximum dry density. The moisture content of the granular fill soils should be within 2% of optimum moisture content at the time of compaction. The moisture content of the clayey soil materials should be maintained between 2% and 4% over optimum moisture content. The maximum dry density of each soil type shall be determined in accordance with ASTM Test Method D1557-91.

Prior to commencement of the brushing operation, a pregrading meeting shall be held at the site. The Developer, Surveyor, Grading Contractor, and Soil Engineer should attend. Our firm should be given at least 3 days notice of the meeting time and date.

Cut Slopes: It is our understanding that 2:1 (horizontal to vertical) cut slopes reaching maximum heights of approximately 35 feet are proposed for this project. Our analysis indicates that slopes up to 50 feet in height, excavated completely within dense, unfractured bedrock at an inclination of 2:1 (horizontal to vertical) or flatter would exhibit a safety factor greater than the generally accepted standard of 1.5. However, it should be noted that localized adverse geologic conditions exposed during the grading procedures may detrimentally reduce this safety factor. These adverse geologic conditions could include, but would not be limited to, fractures and joints dipping out of slope, poorly consolidated overburden soil, excessively weathered bedrock or heavy groundwater seepage.

Observation of the cut slopes during construction should be performed by the Engineering Geologist so that adverse geologic features might be identified.

Additional remedial actions may be required to mitigate the effects of detrimental slope conditions. This may include rock bolting, buttressing, regrading of the slope, or the construction of a retaining wall system. Remedial slope construction should be evaluated and recommended by the Soil Engineer and Engineering Geologist.

Fill Slopes: It is our opinion that fill slopes constructed with any granular, very low expansive soil at an inclination of 2:1 (horizontal to vertical) or flatter will be stable to a maximum height of 40 feet.

Fill slopes shall be keyed into dense natural ground. The key shall extend through all incompetent soil and be established at least 2 feet into dense competent material. The key shall be a minimum of 2 feet deep at the toe of slope and fall with 5% grade toward the interior of the proposed fill areas. The bottom of the key shall have a width of at least 15 feet (Plate No. 27).

All keys must be inspected by the Soil Engineer, Engineering Geologist or their representative in the field.

If feasible, soil material placed within the outer 15 feet of any fill slope, as measured inward horizontally from the face of the slope, shall consist of on-site or imported granular, non-expansive soil material (Expansion Index of 20 or less). Fill slopes constructed with clayey or expansive soils may experience creep and/or surficial failure.

We recommend that slopes be compacted by backrolling with a loaded sheepsfoot roller at vertical intervals not to exceed 4 feet and should be track walked at the completion of each slope. The face of the slopes should be compacted to no less than 90% relative compaction (ASTM D1557-91). This can best be accomplished by over building the slope at least 4 feet and trimming to design finish slope grade.

Surface Drainage: Surface drainage shall be directed away from structures and paved areas. The ponding of water or saturation of soils should not be allowed adjacent to any of the foundations. We recommend that planters be provided with drains and low flow irrigation systems. Gutter, roof drains and other drainage devices shall discharge water away from the structure into surface drains and storm sewers.

Surface water must not be allowed to drain in an uncontrolled manner over the top of any slope or excavation.

The exterior grades should be sloped to drain away from the structures to minimize ponding of water adjacent to the foundations. Minimum site gradients of at least 2% in the landscaped areas and of 1% in the hardscaped areas are recommended in the areas surrounding buildings. These gradients should extend at least 10 feet from the edge of the structure.

To reduce the potential for erosion, the slopes shall be planted as soon as possible after grading. Slope erosion, including sloughing, rilling, and slumping of surface soils may be anticipated if the slopes are left unplanted for a long period of time, especially during rainy seasons. Swales or earth berms are recommended at the top of all permanent slopes to prevent surface water runoff from overtopping the slopes. Animal burrows should be controlled or eliminated since they can serve to collect normal sheet flow on slopes, resulting in rapid and destructive erosion. Erosion control and drainage devices must be installed in compliance with the requirements of the controlling agencies.

Subdrains: A subdrain system shall be installed at the toe of slopes draining into the property, within buttress or stability fills or where fill is proposed over canyons or drainage areas. The final determination for the location of the subdrains shall be made by the Soil Engineer or Engineering Geologist during the site grading.

The subdrain shall consist of a trench at least 36 inches deep and 18 inches wide. Mirafi 140N or Amoco 4547 non-woven geotextile fabric, or an approved equivalent, shall line the bottom and sides of the trench. Four inches of 3/4-inch rock bedding shall be placed on the geotextile at the bottom of the trench. A perforated pipe with a diameter of at least 4 inches shall be placed in the trench with the perforations down. A 6-inch diameter pipe may be necessary where larger volumes of water are anticipated. The pipe shall be ABS schedule 40 (ASTM-D1785) or SDR 21 (ASTM-D2241) or approved equal.

The drainpipe shall have a minimum 1% gradient and shall be centered within the trench horizontally. A minimum of 3 cubic feet of 3/4-inch rock per linear foot of subdrain shall be placed over and around the pipe within the geotextile lined trench. The geotextile shall lap at least 12 inches over the top of the rock. The subdrain shall outlet away from any structures or slopes in an approved legal manner.

Foundation Recommendations

Seismic Site Categorization: The following seismic site categorization parameters may be used for foundation design. These design parameters are based on the information provided in Chapter 16 of the 1997 Uniform Building Code.

Soil Profile Type		$= S_B$
Near Source Factor	N_a	$= 1.0$
Near Source Factor	N_v	$= 1.0$
Seismic Source Type		= B

Footings: The on-site overburden soils (alluvium and colluvium) are not considered suitable for foundation or floor slab support. To provide more uniform support we recommend that proposed structures be entirely supported on compacted soil with an expansion index of 20 or less. Footings should be underlain by at least 2 feet of very low expansive compacted fill. Footings shall be designed with the minimum dimensions and allowable dead plus live load soil bearing values given in the following table:

Footings Established on Compacted Fill

Building Height	Minimum Depth (inches)	Minimum Width (inches)	Allowable Soil Bearing Value (p.s.f.)
One Story	12	12	2,000
Two Story	18	15	2,500

The minimum depth given shall be below **lowest adjacent** finish subgrade. If foundations are proposed adjacent to the top of any slope, we recommend that the footings be deepened to provide a horizontal distance of 8 feet between the outer edge of the footing and the adjacent slope face.

The soil load bearing values presented above may be increased by one-third for short-term loads, including wind or seismic. The soil load bearing values of any imported soil should be determined after its selection but prior to its delivery on-site.

All continuous footings shall be reinforced in accordance with recommendations provided by a Structural Engineer.

Settlements under building loads are expected to be within tolerable limits for the proposed structures.

Concrete Slabs-On-Grade: If the soils are prepared as recommended in this report, concrete slabs-on-grade may be supported entirely on compacted fill. Soil material placed within 4 feet of finish floor should have an expansion index of 20 or less. No cut/fill transitions should be allowed to occur beneath the structure.

To provide protection against vapor or water transmission through the building and floor slabs, we recommend that the slabs-on-grade be underlain by a 4-inch layer of Caltrans Class 2 permeable material or gravel. A suggested gradation for gravel is as follows:

Sieve Size	Percent Passing
3/4"	90-100
No. 4	0-10
No. 100	0-3

If the slab-on-grade is underlain by at least 4 feet of granular compacted fill, the gravel layer may be replaced by 4 inches of clean sand. An impermeable membrane as described below should be placed at the midpoint of the sand layer.

In areas where vinyl or other moisture-sensitive floor coverings are planned or where moisture may be detrimental to the structure's contents, we recommend that the 4-inch-thick gravel layer be overlain by a 10-mil-thick impermeable plastic membrane to provide additional protection against water vapor transmission through the slab. The vapor barrier should be installed in accordance with the manufacturer's instructions. We recommend that the edges and seams (laps) of the vapor barrier be sealed.

To protect the membrane during later concrete work, to facilitate curing of the concrete, and to reduce slab curling, a 2-inch-thick layer of clean sand shall be placed over the membrane. If sand bedding is used, care should be taken during concrete placement to prevent displacement of the sand. A low-slump concrete (4½-inch maximum slump) should be used to further minimize possible curling of the slabs. The concrete slabs should be allowed to cure properly before placing vinyl or other moisture-sensitive floor covering.

The flooring subcontractor should verify through testing of the slab that the vapor transmission does not exceed maximum amounts recommended by the flooring manufacturer.

Slab reinforcing and thickness shall be designed in accordance with the anticipated use of and loadings on the slab and as recommended by the Structural Engineer. Weakened plane joint spacing depth and placement shall be provided by the Structural Engineer.

Transition Areas: Any proposed structures should not be allowed to straddle a cut-fill transition line. Footings and floor slabs should be entirely supported on cut or entirely on fill. The tendency of cut and fill soils to compress differently can frequently result in differential settlement, cracking to portions of the structure and in severe cases structural damage. To reduce the potential for damage due to differential settlement in transition areas, we recommend that on pads where the maximum fill thickness is less than 15 feet, cut areas be over-excavated to a depth of at least 2 feet below the bottom of the deepest footing and replaced with very low expansive soil material compacted to at least 90% of its maximum dry density (ASTM D1557-91). If the fill thickness exceeds 15 feet (including removal and recompaction of incompetent soil), the cut portion should be over-excavated 4 feet below the bottom of the deepest footing. The compacted fill should extend at least 5 feet beyond the building floor plan.

Lateral Resistance: Resistance to lateral loads may be provided by friction at the base of the footings and floor slabs and by the passive resistance of the supporting soils. Allowable values of frictional and passive resistance are presented for the fill soils in the table below. The frictional resistance and the passive resistance of the materials may be combined without reduction in determining the total lateral resistance.

Lateral Resistance Values

Soil Type	Coefficient of Friction	Allowable Passive Pressure (p.s.f./ft. of depth)
Compacted On-Site Fill	0.35	350

Footing Observations: Prior to the placement of reinforcing steel and concrete, all foundation excavations shall be inspected by the Soil Engineer, Engineering Geologist or their representative. Footing excavations shall be cleaned of any loosened soil and debris before placing steel or concrete. Footing excavations should be observed and probed for soft areas. Any soft or disturbed soils shall be over-excavated prior to placement of steel and concrete.

Over-excavation of soils should not be performed in locations that were undercut for transition areas. This would compromise the thickness of the soil supporting the footings. In undercut transition areas loose soils should be recompacted.

Some settlement of the backfill should be anticipated, and any utilities supported therein should be designed to accept differential settlement, particularly at the points of entry to buildings. Also, provisions should be made for some settlement of concrete walks on-grade and other hard-scapes supported on fill.

Pavement Recommendations

General: Samples of the on-site weathered bedrock materials were retrieved from the exploratory excavations. Based on the laboratory test results, the metamorphic bedrock soils and granitic soils have an R-value of 71 and 79, respectively. It is anticipated that these materials, derived from the bedrock, will be predominate on the site. Final pavement design should be based upon representative R-value samples taken after rough grading of the private and public streets.

The subgrade soils should be prepared as recommended in the previous sections describing site preparation and earthwork. Compaction of the subgrade to at least 95%, including trench backfills, will be important for paving support. The preparation of the paving subgrade should be done immediately prior to the placement of the base course. Adequate drainage of the paved surface must be provided to reduce infiltration of water into the subgrade soils.

Preliminary Pavement Design: The required paving thickness and base thickness will depend on the subgrade soils and on the Traffic Index applicable to the intended usage.

Paving sections were estimated for the subgrade soils based on an assumed Traffic Index of 5.0 for the interior residential streets. The asphalt paving sections were established based on the Caltrans design criteria.

Subgrade Option	Assumed Traffic Index	Paving Section
Residential Road (R-value = 71)	5.0	3 Inches Asphaltic Concrete (AC) 6 Inches Aggregate Base (AB)
Residential Road (R-value = 79)	5.0	3 Inches Asphaltic Concrete (AC) 6 Inches Aggregate Base (AB)

It is our understanding that the private roads are intended for light vehicle traffic. Increased maintenance of the private roads may be necessary if they are used for heavy vehicular traffic. We suggest that the final 1-inch thick asphalt pavement layer be applied after 90 percent of the proposed dwellings have been constructed. This will reduce the amount of construction traffic experienced by the final pavement section.

Base Materials: The aggregate base course should meet the specifications for Class 2 Aggregate Base as defined in Section 26 of the State of California, Department of Transportation, Standard Specifications, latest edition. Alternatively, the base course could meet the specifications for untreated base as defined in Section 200-2 of the 1994 Edition of the Standard Specifications for Public Works Construction. The base course should be compacted to at least 95%. Careful inspection is recommended to verify that the specified thickness, or greater, are achieved and that proper construction procedures are used.

Areas that will receive aggregate base shall be properly moistened and recompacted to no less than 95 percent of their maximum dry density to a depth of at least 12 inches below subgrade.

The preceding recommendations are preliminary only. They should be confirmed by sampling and performing R-value tests on the soil material at subgrade elevation on completion of the earthwork.

These recommendations are subject to the review and approval of the governing agencies.

Field Explorations

Subsurface conditions were explored by excavating twenty-one backhoe trenches on July 10 and 11, 2002. The exploratory trenches were 24-inches in width, approximately 15 feet long and extended to depths ranging from 3 to 14 feet. No caving occurred in the trench walls. Groundwater was not observed in any exploratory excavations. The locations of the exploratory excavations are depicted on the Site Plan, Plate No. 1, located in the back pocket of this report.

The surface reconnaissance and subsurface exploration were conducted by our geology and soil engineering personnel. The soils are described in accordance with the Unified Soil Classification System as illustrated on the attached simplified chart (Plate No. 2). In addition, a verbal textural description, the wet color, the apparent moisture and the density or consistency are presented. The density of granular material is given as either very loose, loose, medium dense, dense or very dense. The consistency of silts or clays is given as either very soft, soft, medium stiff, stiff, very stiff or hard. The sampling and logging of our exploratory excavations were performed using standard geotechnical methods. The logs are presented on Plate No. 3 through Plate No. 23. Samples of typical and representative soils were obtained and returned to our laboratory for observation and testing.

Laboratory Testing

Laboratory tests were performed in accordance with the American Society for Testing and Materials (ASTM) test methods or suggested procedures. Test results are shown on Plate No. 24 and Plate No. 25.

Plan Review

Western Soil and Foundation Engineering, Inc. should review the final grading and building plans for this project.

Limitations

The recommendations and opinions expressed in this report reflect our best estimate of the project requirements based on an evaluation of the subsurface soil conditions encountered at the subsurface exploration locations and the assumption that the soil conditions do not deviate appreciably from those encountered. It should be recognized that the performance of the foundations and/or cut and fill slopes may be influenced by undisclosed or unforeseen variations in the soil conditions that may occur in the intermediate and unexplored areas. Any unusual conditions not covered in this report that are encountered during site development should be brought to the attention of the geotechnical consultant so that they may make modifications, if necessary.

This office should be advised of any changes in the project scope so that it may be determined if the recommendations contained herein are appropriate. This should be verified in writing or modified by a written addendum.

It is recommended that Western Soil and Foundation Engineering, Inc. be retained to provide continuous geotechnical engineering services during the earthwork operations. This is to observe compliance with the design concepts, specifications or recommendations and to allow design changes in the event that subsurface conditions differ from those anticipated prior to start of construction. Western Soil and Foundation Engineering, Inc. and/or our consultants, will not be held responsible for earthwork of any kind performed without our observation, inspection and testing.

The findings of this report are valid as of this date. Changes in the condition of a property can, however, occur with the passage of time, whether they be due to natural processes or the work of man on this or adjacent properties. In addition, changes in the State-of-the-Art and/or Government Codes may occur. Due to such changes, the findings of the report may be invalidated wholly or in part by changes beyond our control. Therefore, this report should not be relied upon after a period of one year without a review by us verifying the suitability of the conclusions and recommendations.

We will be responsible for our data, interpretations, and recommendations, but shall not be responsible for the interpretations by others of the information developed. Our services consist of professional consultation and observation only, and no warranty of any kind whatsoever, express or implied, is made or intended in connection with the work performed or to be performed by us, or by our proposal for consulting or other services, or by our furnishing of oral or written reports or findings.

It is the responsibility of the Client or the Client's representative to ensure that the information and recommendations contained herein are brought to the attention of the engineer and architect for the project and incorporated into the project's plans and specifications. It is further the responsibility of the Client to take the necessary measures to ensure that the contractor and sub-contractors carry out such recommendations during construction.

Respectfully submitted,
WESTERN SOIL AND FOUNDATION ENGINEERING, INC.

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